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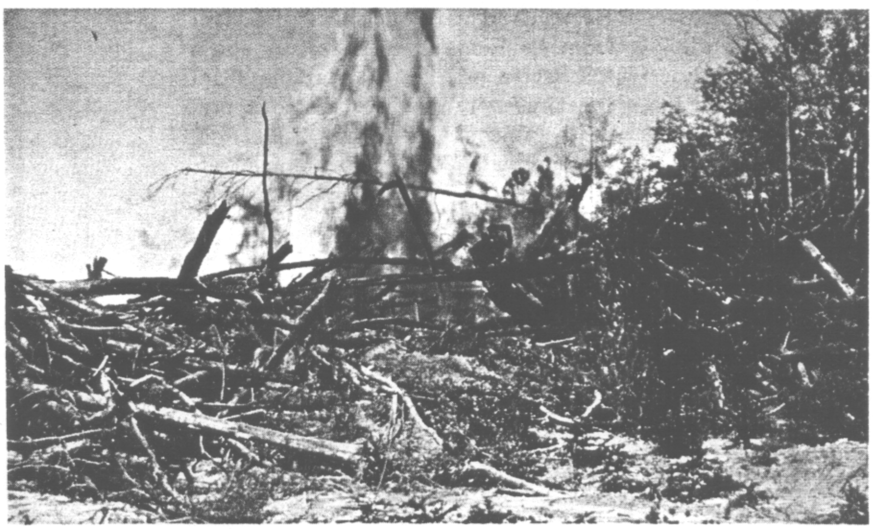


ESTIMATING QUANTITIES OF WINDROWED FOREST RESIDUES...

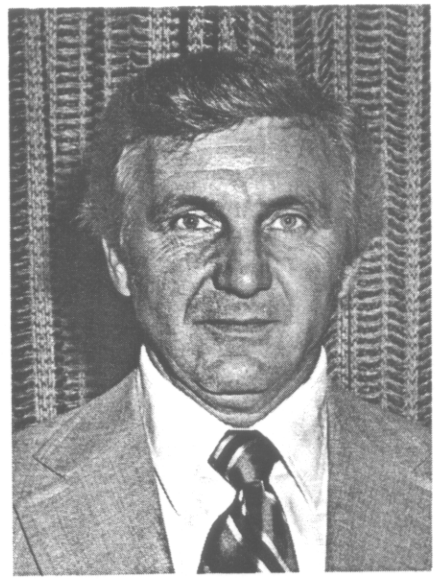
A MANAGEMENT TOOL FOR INCREASED BIOMASS UTILIZATION

BY W.H. McNAB
AND J.R. SAUCIER

RESEARCH DIVISION

GEORGIA FORESTRY COMMISSION

AUTHORS



WILLIAM H. McNAB is Silviculturist with the Southeastern Forest Experiment Station at Athens, Georgia. He has a BS degree in Forest Management and MS in Silviculture, both from the University of Florida. He is currently a member of the Utilization of Southern Timber Research Work Unit, where he works mainly on problems related to the effects of silvicultural practices on biomass yields and utilization of forest residues.

JOSEPH R. SAUCIER is Research Scientist with the Southeastern Forest Experiment Station at Athens, Georgia. He received a BS degree in Forestry from Louisiana State University and a MS degree in Wood Technology from the University of Georgia. He is presently Project Leader of the Utilization of Southern Timber Research Work Unit.

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INTRODUCTION

Windrowing is commonly used for site preparation in harvested clearcuts in Georgia; logging residues and unmerchantable standing trees are pushed into elongated piles (Figure 1). Windrowing is especially used on sites where naturally established pine has been removed from mixed pine-hardwood stands, leaving low-grade hardwoods which must be removed before pine regeneration. Often the landowner is not aware of the amount of hardwood present or how its use, such as whole-tree chipping for fuel wood, can provide additional income and reduce site preparation costs[1/]. However, where the scattered residual trees have been concentrated into piles, the quantity available becomes apparent. At the present time, it may not be feasible to use the windrow material except possibly for firewood. By estimating the quantity and value of residues contained in the windrow, the landowner can easily evaluate the potential for greater harvest yields on similar sites. The purpose of this report is to describe a simple process developed for the landowner to evaluate his windrowed biomass.

1/ Butts, P.M. and D.N. Preston. 1979. Whole tree chipping...A forest management tool. Ga. For. Res. Pap. No. 4, 8 p.

Figure 1.--Windrows of forest residues from clearcut harvesting pine-hardwood sites may contain large amounts of unmerchantable species that could be economically utilized during logging by whole tree chipping for fuel wood.

STUDY PROCEDURES

Windrows were studied on three typical pine-hardwood sites on the Oconee National Forest. Sample points at 27 windrows were selected and 1-foot-wide paths were cut through the windrow with a chain saw. The exposed cross-sectional area of the windrow was measured, along with each piece of wood 0.25 inch or larger in diameter. A total of 54 transects were cut in windrows that ranged in size from 2 to 8 feet in height and 2 to 17 feet in width (Table 1). Other observations were also made including average size of windrow material and species composition. No residues were actually weighed, but the estimated weight of each 1-foot section was calculated from published values of air-dry density. These values were totaled to obtain the wood residue weight of the 1-foot-wide section through the windrow. This set of 54 values of wood residue weight along with other measurements made of the windrow at each sample point, was then analyzed. Our main purpose was to determine if certain easily measured characteristics of the windrow were correlated and could be used to predict the weight of wood present.

RESULTS

We found that the amount of wood at a given sample point along a windrow correlated primarily with two factors:

1. The average diameter of wood residues greater than 3 inches observed at that point, and
2. The height of the windrow.

It is logical that these factors should be important. Stems and crowns of small diameter trees are not heavy enough to become tightly packed in the windrows by their own weight. Larger trees are heavier and tend to compress the windrow content into a more compact mass. However, as the height of the windrow increased, the total amount of wood residue tended to decrease because more holes and openings between the tree stems were present, which did not add to the total overall weight. A prediction equation was derived which expresses the relationship between wood residue diameter and windrow height as it affects the proportion of wood in the windrow. The equation can be intrepreted as predicting the proportion of solid wood present in a typical 1-cubic-foot section through the windrow.

Table 2. –Dry weight of residue per cubic foot of windrow cross-sectional volume may be estimated from average size of residue greater than 3-inches in diameter on the windrow surface and average maximum windrow height.

Windrow height (ft)	Residue diameter (in) 4	6	8	10	12	14	16
	lb/ft^3						
4	3.0	6.4	8.6	10.0	11.1	11.8	12.4
5	2.7	6.0	8.1	9.6	10.6	11.3	11.9
6	2.6	5.8	7.8	9.3	10.3	11.0	11.6
7	2.4	5.6	7.6	9.0	10.0	10.8	11.3
8	2.4	5.5	7.5	8.9	9.9	10.6	11.2
9	2.3	5.4	7.4	8.8	9.7	10.6	11.0
10	2.3	5.3	7.3	8.7	9.6	10.4	10.9

APPLICATION

Weight and volume of windrowed residues can be easily estimated after information is collected on the following:

1. Average diameter of residues
2. Average maximum windrow height
3. Average horizontal distance to windrow midpoint
4. Total length of windrow on the tract

As noted previously, residue diameter and maximum height are used to estimate

Table 3. –Adjusted windrow cross-sectional volume may be estimated using average height and mid distance windrow width, as shown in Figure 2.

Windrow height (ft.)	Windrow width to center (ft.) 4	5	6	7	8	9	10
	Feet^3						
4	22	27	32	37	41	46	51
5	27	33	39	45	51	57	63
6	32	39	46	53	61	68	75
7	37	45	53	62	70	78	87
8	41	51	61	70	80	89	99
9	46	57	68	78	89	100	110
10	51	63	75	87	99	110	122

Table 1. Mean physical characteristics of windrows sampled on three pine-hardwood clearcut sites on the Oconee National Forest.

Location	Windrows measured	Transects sampled	Windrow height Mean	Minimum	Maximum	Windrow width Mean	Mimimum	Maximum	Cross-section profile area
	Number		Feet						ft^2
I	6	6	3.4	2.0	6.0	6.7	5.0	11.0	24.4
II	17	33	3.9	1.8	8.1	10.6	3.4	16.8	29.8
III	5	15	3.3	1.8	5.3	9.3	2.5	17.1	23.4
Mean	28	54	3.7	- -	- -	9.8	- -	- - -	27.4

the volume of wood residue per cubic foot of windrow volume. This wood volume measurement may be changed to units of weight by multiplying the proportion by 35 pounds per cubic foot, an average air-dry density (12 percent moisture content) of hardwoods. Values of residue weight per cubic foot of windrow cross-sectional volume may be obtained directly from Table 2.

A measure of total windrow cross-sectional area (or volume, if a section 1-foot-wide is assumed) is then needed to determine estimated weight of residues through the entire windrow. Windrow cross-sectional area may be easily obtained at the sample points by determining height and horizontal distance to windrow center as shown in Figure 2, and then multiplying as if finding the area of a rectangle. Note also from Figure 2 that the typical windrow was not symetrical, and that an average of 19 percent more area was present in the windrow cross-sectional area as compared to the assumed symmetrical proportions of a triangle. Table 3 may be used to determine the cross-sectional area of the windrow by using the height and midwidth distance at the sampling points.

The final step in determining weight of residue at a typical point along the windrow is merely to multiply the value of wood proportion obtained in Table 2 by the cross-sectional volume of the windrow obtained in Table 3. Of course, length of windrow on the entire tract would then be needed to estimate total biomass. An example of these calculations is shown below.

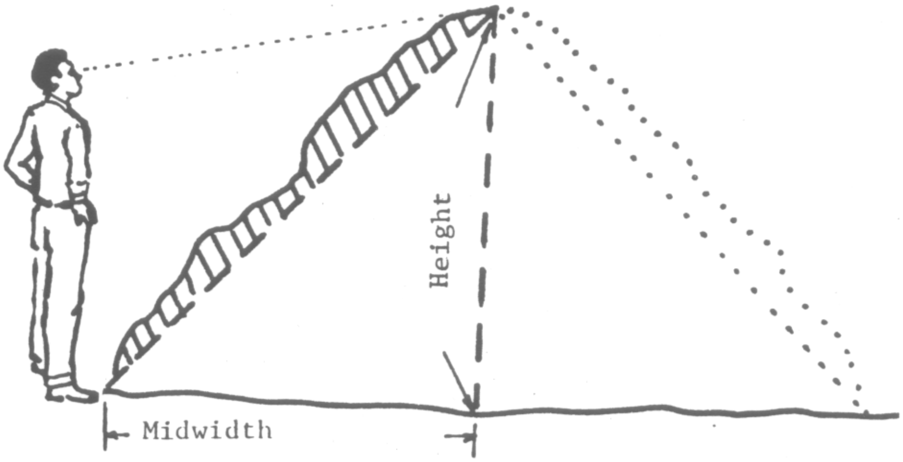

Figure 2. --Windrow cross-sectional area was estimated in the field by assuming the pile was triangular shaped, and then determining maximum height and width to that point. This simple method usually underestimated the actual area by about 19 percent, due to surface irregularities (shaded portion). The opposite, unseen portion of the windrow was assumed to be symmetrical with the observed portion.

EXAMPLE

In practice, estimates of mean residue diameter and mean windrow dimensions should represent the entire tract. These data may be obtained by systematically walking along one side of the windrow and stopping at predetermined distances, about every 500 feet. At least 30 samples should be obtained. Consider the following hypothetical data collected from 4 sample points along a windrow made from residues on a 10-acre tract:

Sample point	Residue diameter	Windrow Height	Windrow Mid distance	Sample interval
	in.	ft.	ft.	ft.
1	8	6	10	500
2	4	6	6	500
3	4	8	12	550
4	16	4	8	450
Total	32	24	36	2000
Average	8*	6	9	--

*Quadratic mean diameter should be used for greater accuracy in estimating average diameter.

From Table 2, we determine that weight of wood per cubic foot of windrow volume is 7.8 pounds per cubic foot. Using Table 3, windrow cross-sectional volume is found to be 68 cubic feet. Therefore, estimated weight per average foot of cross-sectional area of the windrow is equal to 7.8 pounds per cubic foot times 68 cubic feet equals 530 pounds per foot of windrow length. For the entire length of windrow, the estimated weight is 530 pounds per foot times 2,000 feet of length equals 1,060,800 pounds (530 tons) or 53 tons per acre.

SUMMARY

This procedure for estimating weight of residue in a windrow is simple in concept and may be quickly and easily applied in the field. A wide range of sampling has not been completed, so the results should be interpreted as a rough estimate of the biomass present on a tract. The effect of soil in altering these relationships has not been determined, because residues were sheared with a sharp blade and very lightly raked on the Oconee Forest and no soil was found in the windrows. If soil was present, windrow dimensions maybe slightly larger and residue volumes could be slightly overestimated. If stumps are uprooted and pushed into the windrows, larger overestimates could occur. At the present time, this method should be considered primarily as a management tool to encourage greater residue utilization on other harvested tracts.

Currently, the best opportunity for greater utilization of unmerchantable hardwoods consists of total tree chipping for fuel wood. A simple method of estimating the quantity of fuel wood per acre before harvest is described in Georgia Forest Research Paper 7[2/]. If the inventory cruise indicates the amount of potentially useable biomass is sizeable, it could be marketed when the merchantable portion of the stand is harvested.

2/ Phillips, Douglas R. and Joseph R. Saucier. 1979. A test of prediction equations for estimating hardwood understory and total stand biomass. Ga. For. Res. Pap. No. 7, 8 p

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A. Ray Shirley, Director
John W. Mixon, Chief of Forest Research

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